Knowledge Spillovers and the Timing of Foreign Entry

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Abstract

We analyze how foreign presence affects local firm productivity. We relax the standard implicit assumption that spillovers are immediate and permanent. We find that spillovers are dynamic. Foreign entry of a majority foreign owned firm has a short run negative effect on the productivity of local competitors, which is more than offset by a longer run positive effect. The entry of minority foreign owned firms has an immediate, though short-lived, positive effect on local suppliers. The entry of majority foreign owned firms also improves the productivity of local suppliers, but the effect materializes later and lasts longer.

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1 Introduction

When a firm invests in a foreign country, it often brings with it proprietary technology to compete successfully with indigenous firms (Markusen, 1995). Believing that this transferred technology will be adopted by domestic firms, host country policymakers often try to implement policies to attract foreign direct investment (FDI). Unfortunately, the literature surveys of Görg and Greenaway (2004) and Crespo and Fontoura (2007) on FDI spillovers conclude that there is no clear evidence of aggregate positive FDI spillovers.

FDI spillovers are commonly analyzed in a production function framework. Total factor productivity at the firm level is obtained in a first step estimation and in a second step estimation FDI spillover variables are introduced as additional 'input' variables to explain domestic firms' productivity. The size and significance of the resulting coefficients are then taken as evidence of FDI spillovers. The literature distinguishes between spillovers to firms in the same industries (horizontal spillovers) and spillovers to firms in other industries linked to the foreign firm through the supply chain (vertical –back- and forward– spillovers). These are illustrated in figure 1. Horizontal spillovers have received widespread attention, while the vertical spillover discussion that was launched by McAleese and McDonald (1978) and Lall (1980) was reignited by Schoors and van der Tol (2002) and took off with the contribution of Smarzynska Javorcik (2004). Following new theoretical insights that stress the importance of firm level heterogeneity in the study of firms' participation in international markets (see e.g. Melitz, 2003 and Helpman et al., 2004), the spillover literature has analyzed firm- (or industry-) specific characteristics that may mediate any positive spillovers. These characteristics most often concern domestic firms' characteristics such as measures for absorptive capability (see a.o. Merlevede and Schoors, 2007). The attention for foreign firms' characteristics has been more limited (Marin and Bell, 2006, and Javorcik and Spatareanu, 2008, are the exceptions).

This paper adds dynamic aspects to the analysis of FDI spillovers. Although the literature has acknowledged that FDI spillovers effects may require time to materialize, the empirical literature has addressed this issue merely by using lagged values of spillover variables. This approach is unsatisfactory. Since spillover variables are typically based on foreign firms' share in total industry output (or employment), the spillover effect of all foreign investment, new and old, is lumped together in one variable. Merely lagging the spillover variables does not adequately address the dynamic nature of spillovers, since lagged variables still lump together the effect of all previous foreign investment in one variable. The root of the problem is that this aggregate approach implicitly assumes that the contemporaneous spillover effect of a foreign firm that entered in a given year t is identical to that of a foreign firm that

entered in any other year $-t$. This does not correspond with our understanding of the theoretical transmission channels of spillover effects. Teece (1977) for example already suggests that technology imitation and worker mobility might be important channels of horizontal spillovers, but neither the mobility of workers trained by foreign firms, nor technology imitation are likely to materialize in the very short run. Likewise, vertical spillovers driven by access to better inputs produced by foreign firms or by supplying inputs to multinational companies are not necessarily instantaneous nor permanent. There is some circumstantial evidence that timing may be important for spillover effects. For a panel (1982-95) of firms in the Irish electronics sector Görg and Ruane (2001) find indications that foreign firms start off with a relatively low extent of local linkages, but as they get accustomed, they proceed to develop more local input linkages. Giroud (2007) confirms this by comparing foreign firms' perceived impact on local suppliers in Malaysia and Vietnam. Local suppliers benefit significantly less form foreign presence in Vietnam than in Malaysia, where multinationals have been present for a longer period. Based on their AB Volvo case study Ivarsson and Alvstam (2005) conclude that technology transfer to suppliers seems to be more efficient in Volvo's older plants. The business literature further suggests that technology is not always easily or rapidly transferred within multinationals (see e.g. Urata and Kawai, 2000) which may also give rise to specific time patterns in the transfer of technology to foreign affiliates and the resulting spillovers. Given the above, the current 'static' empirical approach may be inadequate to identify spillovers accurately. In addition to providing a better link between theory and test, understanding the dynamic nature of spillovers also has clear policy relevance for e.g. the fiscal treatment of foreign investment. If foreign entry spills over in a positive level shift of domestic firms' productivity, a temporary tax holiday seems appropriate (left aside e.g. employment considerations in the foreign firms), while a more permanent tax incentive scheme may be warranted if foreign firms are a source of a more continuous flow of positive spillover effects.

Our results indicate the spillover effects of foreign investment on domestic firm productivity are dynamic indeed. Let us first look at the horizontal effects. Domestic firms' productivity seems to benefit from the presence of majority foreign owned firms in their industry, although the majority foreign owned firm needs to be present for at least four years in the host country before domestic firms experience a positive contribution to their productivity growth. This may result from the fact that domestic firms need to familiarize themselves with the advanced technology introduced by majority owned foreign firms, or alternatively from the fact that worker mobility can only improve domestic firm productivity if workers trained (long enough) by the foreign entrant later join a domestic firm or set up their own domestic firm. The impact of majority foreign owned firms that entered the

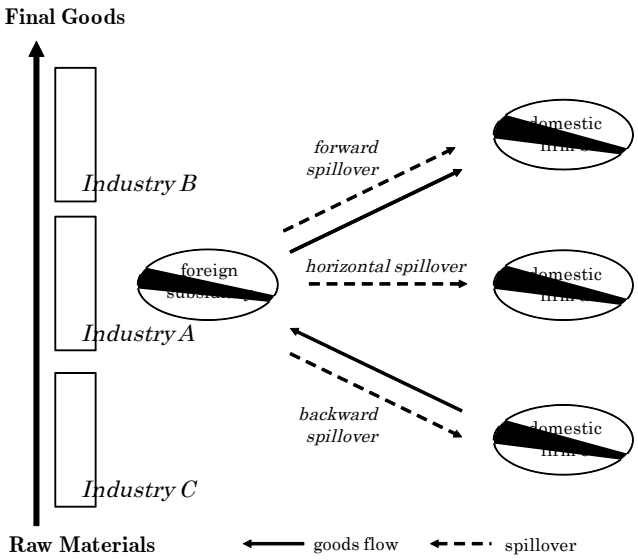

Figure 1: Horizontal, forward and backward spillovers through the supply chain

domestic economy more recently is negative, pointing to a short run negative competition effect. The impact of the entry of minority foreign owned firms on their local competitors' productivity is more moderate.

These minority foreign owned firms do however generate immediate and strong positive backward spillover effects to their local suppliers. The first two years after entry, domestic firms enjoy a substantial contribution to productivity growth when supplying the minority foreign owned entrant. If minority foreign owned firms have entered the domestic economy longer ago, the positive backward spillover effect fades away. Backward spillovers from majority foreign owned firms are also positive and significant but not immediate. Foreign firms need to be present for at least a full year before domestic firms are able to grasp positive backward spillover effects. Although the effect lasts longer than for minority foreign owned firms, it also fades out in the longer run. Most likely domestic firms have closer ties with minority than majority foreign owned firms (because of the majority domestic participation in the former), which ensures that positive spillovers of minority foreign investment materialize quicker. But since the minority foreign owner has to share profits with a local partner and has more reasons to fear technology leakage, he may bring in less advanced technology, which makes the spillover effect of foreign minority investment smaller and fade out faster. We do not find strong evidence for the existence of forward spillovers, a finding that is in line with most of the literature (see e.g. Smarzynska Javorcik, 2004, and Smarzynska Javorcik and Spatareanu, 2008).

This paper continues as follows. In section 2, we provide a description of our dynamic approach FDI spillover. Section 3 lays out the data and estimation strategy. Results and interpretation are provided in section 4. Section 5 concludes.

2 A dynamic approach to spillovers

Horizontal spillovers run from a foreign firm to a host country firm in the same industry. Teece (1977) suggests two main channels for horizontal spillovers: technology imitation (the demonstration effect) and mobility of workers trained by foreign firms (see also Fosfuri et al., 2001, and Görg and Strobl, 2005). Marin and Bell (2006) find that training activities by foreign subsidiaries are related to stronger horizontal spillovers. Foreign entry may also fuel competition in the domestic market. Fiercer competition urges host country firms to either use existing technologies and resources more efficiently or adopt new technologies and organizational practices, which provides another important channel of horizontal spillovers (see Aitken and Harrison, 1999, and Glass and Saggi, 2002). None of these effects is necessarily positive. Labor market dynamics may entail negative spillovers such as a brain drain of local talent to foreign firms to the detriment of local firm productivity (Blalock and Gertler, 2004) or an overall increase in wages irrespective of productivity improvements caused by foreign firms paying higher wages (Aitken et al., 1996). Where foreign technology is easily copied, the foreign investor may choose to avoid leakage costs on state-of-the-art technology by transferring technology that is only marginally superior to technology found in the host country (see Glass and Saggi, 1998). Such policies obviously limit the scope for horizontal spillovers via demonstration effects. The higher productivity of foreign affiliates may also lead to lower prices or less demand for the products of domestic competitors. If domestic firms fail to raise productivity in response to the increased competition, they will be pushed up their average cost curves. Ultimately, domestic producers may not merely fall behind, but fall by the wayside, driven out of business by the shock of foreign entry (see Aitken and Harrison, 1999, on this market-stealing effect). These partial effects are hard to disentangle empirically and a general measure for horizontal spillovers will identify the net effect of all these channels.

Figure 1 shows how backward spillovers run from the foreign firm to its upstream local suppliers. Thus, even if foreign firms attempt to minimize their technology leakage to direct competitors (horizontal effect), they may still want to assist their local suppliers in providing inputs of sufficient quality in order to realize the full benefits of their investment. In other words, they want the inputs from the host country to be lower cost yet similar in quality to inputs in the home country. If the foreign firm decides to source locally, it may transfer

technology to more than one domestic supplier and encourage upstream technology diffusion to circumvent a hold-up problem. Rodriguez-Clare (1996) shows that the backward linkage effect is more likely to be favorable when the good produced by the foreign firm uses intermediate goods intensively and when the home and host countries are similar in terms of the variety of intermediate goods produced. Under reversed conditions, the backward linkage effect could even damage the host country's economy. Figure 1 also suggests how a forward spillover goes from the foreign firm to its downstream local buyer of inputs. The availability of better inputs due to foreign investment enhances the productivity of firms that use these inputs. However, there is also a danger that inputs produced locally by foreign firms are more expensive and less adapted to local requirements. In this case there would be a negative forward spillover.

The current empirical literature implicitly assumes spillovers to be constant over time, at best only allowing spillover effects to kick in with a time lag. This is shown as the bold line in figure 2. Allowing for a time lag would cause the bold line to shift to the right. One can easily infer that whether a firm has been present for one, 10 or 20 years in the host country is assumed irrelevant for the spillover effect. In the introduction however, we discussed that most spillovers, horizontal or vertical, are probably dynamic by nature. Workers need to receive training and adsorb technologies before they can move to a domestic firm to improve the latter's productivity. Enhanced foreign competition may initially hurt domestic companies before it makes them better. If foreign affiliates tend to increase their local sourcing over time, backward spillovers will not rise to their full effect immediately. The presence of better foreign inputs probably requires an adaptation effort, before domestic firms can reap the full benefits of it. The dashed line in figure 2 shows a hypothetical dynamic pattern where the spillover effect is negative at first, say there is an adjustment cost, then becomes positive and finally fades out.

Our dynamic approach requires that we employ a measure of spillover variables that differs from the current literature. Typically, the horizontal spillover variable $Horizontal_{jt}$ captures the degree of foreign presence in sector j at time t and is measured as:

$$Horizontal_{jt} = \frac{\sum_{i \in j} F_{it} * Y_{it}}{\sum_{i \in j} Y_{it}} \tag{1}$$

where Y_{it} is the output produced by firm i in year t. $Horizontal_{jt}$ is industry j's share of output that is produced by foreign firms. Foreign firms are identified by F_{it}. A firm is classified as foreign when foreign participation exceeds 10%.[1] In the literature F_{it} either is the exact share of foreign participation in firm i in year t (but set to zero if it is smaller than

[1] This threshold level is commonly applied (e.g. by the OECD or the IMF) in FDI definitions.

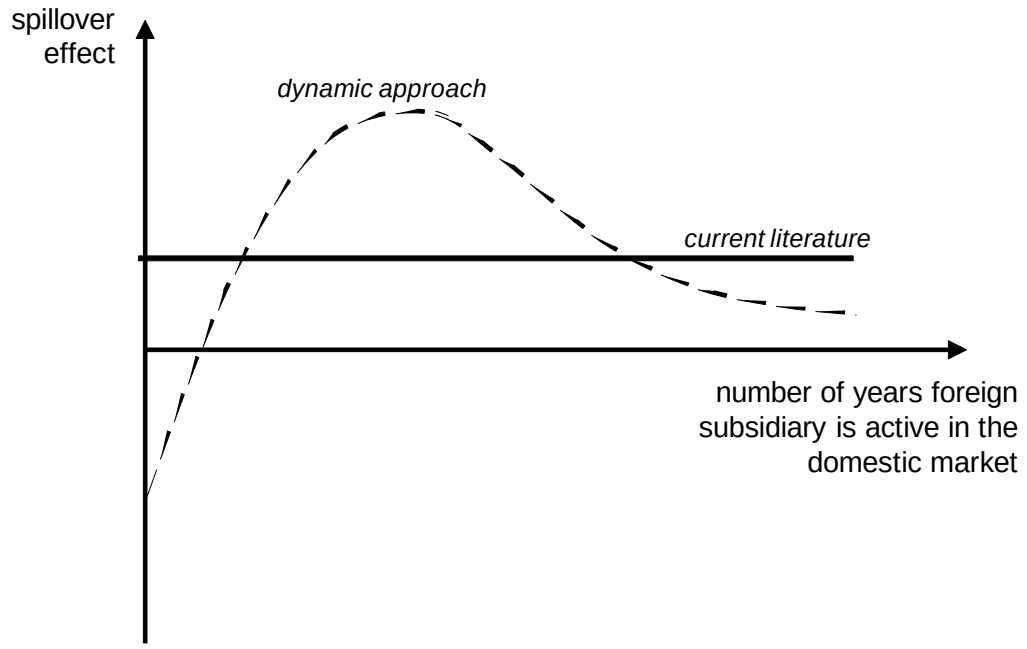

Figure 2: Spillover effects to domestic firms' productivity as a function of the number of years of activity in the domestic market by the foreign firm: current literature versus dynamic approach

0.1), or alternatively, F_{it} is a dummy variable that takes the value 1 if firm i is foreign in year t and 0 otherwise. In our empirical analysis below we will consider both a dummy and share version of our spillover variables.

For the measurement of the backward spillover variable $Backward_{jt}$, the literature employs:

$$Backward_{jt} = \sum_{k \ if \ k \neq j} \gamma_{jkt} * Horizontal_{kt} \tag{2}$$

where γ_{jkt} is the proportion of industry j's output supplied to sourcing industry k at time t. The γs are calculated from (possibly time-varying) IO-tables for intermediate consumption. Inputs sold within the firm's industry are excluded ($k \neq j$) because this is captured by $Horizontal_{jt}$. Since firms cannot easily or quickly switch industries to buy inputs, this approach avoids the problem of endogeneity by using the share of industry output sold to downstream domestic markets k with some level of foreign presence $Horizontal_{kt}$. Employing the share of firm output sold to foreign firms in different industries would cause endogeneity problems if the latter prefer to buy inputs from more productive domestic firms. In the same

spirit, the forward spillover variable $Forward_{jt}$ is defined as:

$$Forward_{jt} = \sum_{l \ if \ l \neq j} \delta_{jlt} * Horizontal_{lt} \tag{3}$$

where the IO-tables reveal the proportion δ_{jlt} of industry j's inputs purchased from upstream industries l. Inputs purchased within the industry ($l \neq j$) are again excluded, since this is already captured by $Horizontal$. $Horizontal_{jt}$, $Backward_{jt}$, and $Forward_{jt}$ are then related to domestic firms' productivity to infer the direction, magnitude and significance of spillovers.

As pointed out in the introduction, this typical definition of $Horizontal_{jt}$ in (1) lumps together all current and previous foreign investment in a single spillover variable and therefore implicitly assumes that the impact of a foreign firm on the domestic firm's productivity is constant over time. Since theory allows us to suspect that spillovers might be dynamic, rather than static, we define "e" different versions of the horizontal spillover variable instead of the single measure in (1) in order to capture these possible dynamic effects. Specifically we want to test whether the time since entry has an impact on the spillover effect. Therefore we define the variable $Horizontal^e_{jt}$ in (4) as industry j's share of output at time t produced by foreign firms that have been present in the host (domestic) economy for more than $e-1$, but less than e years (alternatively firms that entered between $t-e$ and $t-e+1$).

$$Horizontal^e_{jt} = \left. \frac{\sum_i \widetilde{F}^e_{i,t} * Y_{it}}{\sum_i Y_{it}} \right|_{\Omega(i,t-e)} \tag{4}$$

where $\widetilde{F}^e_{i,t}$ is set to one if

$$\left(\sum_{v=0}^{e-1} F_{i,t-v} = e \right) \ \wedge \ \left(\sum_{w=e}^{\infty} F_{i,t-w} = 0 \right)$$

and to zero otherwise.

For e equal to 2, $Horizontal^2_{jt}$ is industry j's share of output that is produced by foreign firms that have entered the domestic market more then one, but less than two years before t. Time varying definitions for $Backward^e_{jt}$, and $Forward^e_{jt}$ follow from (2) and (3) above

$$Backward^e_{jt} = \sum_{k \ if \ k \neq j} \gamma_{jkt} * Horizontal^e_{kt} \tag{5}$$

$$Forward^e_{jt} = \sum_{l \ if \ l \neq j} \delta_{jlt} * Horizontal^e_{lt} \tag{6}$$

3 Empirical approach and Data

3.1 Empirical approach

FDI spillovers are commonly analyzed in a production function framework. Total factor productivity at the firm level is obtained in a first step estimation and in a second step the FDI spillover variables *Horizontal*, *Backward*, and *Forward*, together with some further controls are treated as additional 'input' explaining domestic firms' productivity. The resulting coefficients are then taken as evidence of FDI spillover effects. The careful estimation of production functions is thus an important building block in the analysis. The basic problem in estimating productivity is that firms react to firm-specific productivity shocks that are often not observed by the researcher. Griliches and Mairesse (1995) provide a detailed account of this problem and make the case that inputs should be treated as endogenous variables since they are chosen on the basis of the firm's unobservable assessment of its productivity. OLS estimates of production functions therefore yield biased estimates of factor shares and biased estimates of productivity.[2] The semi-parametric approaches by Olley and Pakes (1996) (OP) and a more recent modification of it by Levinsohn and Petrin (2003) (LP), and the dynamic panel data approach by Blundell and Bond (1998) (DPD) are alternative methodologies to overcome the endogeneity bias in estimating production functions. Both types of methodologies have been widely used in the recent literature on firm level heterogeneity for derivation of total factor productivity measures. More recently, Ackerberg et al. (2008) (ACF) argue that, while there are some solid and intuitive identification ideas in the paper by Levinsohn and Petrin (2003), their semi-parametric techniques suffer from collinearity problems casting doubt on the methodology. They suggest alternative methodologies that make use of the ideas in these papers, but do not suffer from these collinearity problems. Ackerberg et al. (2008) also compare their semi-parametric approach to the estimators used in the dynamic panel literature and conclude that one may try both techniques in the absence of clear guidance from data considerations and/or a-priori beliefs about a particular production process. While details on the methodology appear in those papers, it is sufficient here to note that they allow for firm-specific productivity differences that exhibit idiosyncratic changes over time.

We estimate domestic industry production functions for each Nace 2-digit manufacturing industry j in the period 1996–2005 separately, excluding firms that are foreign at some point in time from the estimation. Capital, labor, and material inputs elasticities are thus industry-specific. A measure of total factor productivity tfp_{ijt} for firm i in industry j at

[2] Specifically, the coefficient of labor is biased upwards, while the capital coefficient is biased downwards.

time t is obtained as the difference between output and capital, labor, and material inputs, multiplied by their estimated coefficients:

$$tfp_{ijt} = Y_{ijt} - \widehat{\beta}_{lj} l_{ijt} - \widehat{\beta}_{kj} k_{ijt} - \widehat{\beta}_{mj} m_{ijt} \tag{7}$$

In the second step, we relate tfp_{ijt} to a firm specific effect, a vector of spillover variables, $\mathbf{FDI}_{jt}$, a control for competition, and time dummies (α_t). Note that (8) now pools firms from all industries together in one large panel, whereas (7) is estimated by industry. This specification follows the standard in the literature (e.g. Smarzynska Javorcik, 2004)

$$tfp_{ijt} = \alpha_i + \Psi_1 f\left(\mathbf{FDI}_{jt-1}\right) + \alpha_2 H_{jt} + \alpha_t + \varepsilon_{ijt} \tag{8}$$

The vector of spillover variables ($\mathbf{FDI}_{jt-1}$) covers the different horizontal and vertical spillover variables described in (1)-(6). Considering the time span of our dataset (1996-2005) we opt to include $Horizontal^1_{jt-1}$ to $Horizontal^4_{jt-1}$ and create a variable $Horizontal^{5+}_{jt-1}$ which lumps together all foreign firms that have been present for at least four years on the domestic market. This reduces the time span of our dependent variable 2000-2005 because of missing values for $Horizontal^2_{jt}$ to $Horizontal^{5+}_{jt}$. We control for a competition index, H_{jt}, measured by the Herfindahl index.

Specification (8) is first-differenced and then estimated by OLS, including industry (α_j) and region dummies (α_r). Because $\mathbf{FDI}_{jt}$ and H_{jt} are defined at the industry level, and estimations are performed at the firm level, standard errors need to be adjusted (Moulton, 1990). Standard errors are clustered for all observations in the same industry and year. This results in (9) as final specification to be estimated.

$$\Delta tfp_{ijrt} = \Psi_1 \Delta f\left(\mathbf{FDI}_{jt-1}\right) + \alpha_2 \Delta H_{jt} + \alpha_t + \alpha_j + \alpha_r + \varepsilon_{ijrt} \tag{9}$$

3.2 Data

We use firm-level data for a panel of Romanian manufacturing firms during 1996–2005. Because most foreign investment entered Romania after 1996, Romania makes a very good candidate to study the dynamic impact of recent foreign investment on domestic firm productivity. As can be seen from figure 3 Romania started attracting large FDI inflows only late in transition. The slow pace in the early 1990s of both privatization efforts and market-oriented reform in general made Romania an unattractive place to invest relative to the other transition countries in Central and Eastern Europe. It was only in 1997 that Romania really embarked on privatization. In 2004 FDI inflows took off on a larger scale. Early 2008 Austria (21.4%), The Netherlands (16.3%), Germany (11.7%), France (8.8%) and Greece

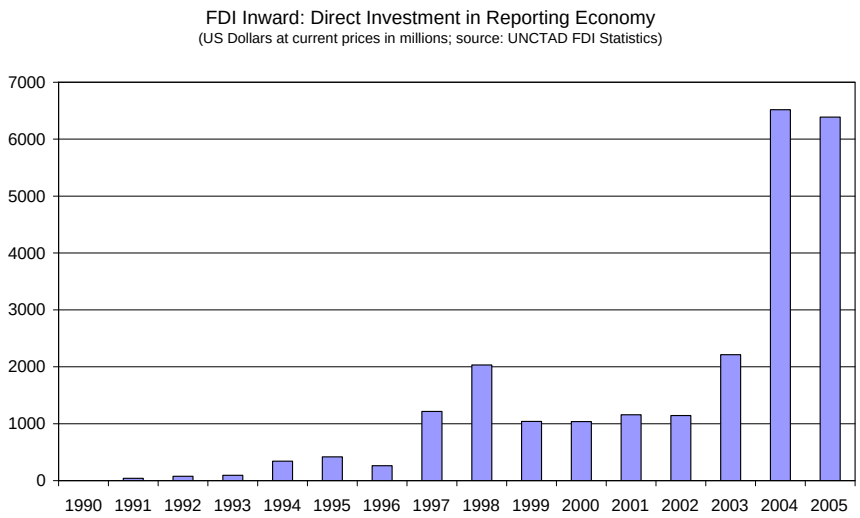

Figure 3: Foreign Direct Investment in Romania 1990-2005

(7.5%) were the most import home countries of foreign firms in Romania. Manufacturing accounted for about 40% of total foreign investment, metal (7.5%) and food and tobacco (5.2%) are the most important subsectors. Banking and insurance (23.3%) , wholesale and retail (14%), and telecommunication (6,5%) are the other important industries in terms of FDI.

Our firm-level data are taken from the Amadeus database by Bureau Van Dijk. Amadeus is a pan-European database of financial information on public and private companies. About every month Bureau Van Dijk issues a new DVD with updated information. Therefore a single issue contains only the latest information on ownership. Firms that go out of business are dropped from the database fairly rapidly. Because Bureau Van Dijk updates individual ownership links between legal entities rather than the full ownership structure of a given firm, the ownership information on a specific DVD-issue often consists of a number of ownership links with different dates, referring to the last verification of the specific links. To construct our dataset with entry, exit, and time-specific foreign entry in local Romanian firms, we therefore employed a series of different issues of the database. However, since ownership information is gathered at irregular intervals, we do not have ownership information for all years, owners, and firms.[3] Given this specificities of Amadeus, we first created a dataset at the firm-owner-year-level with the available information from Amadeus. We then filled out

[3]Identifying the same owner in different issues is not always straightforward since an ID is only listed in case the owner is a firm that is listed in Amadeus itself. For all other owners matching is done on the basis of the name. Differences in spacings, plurals, addition to the name of a company-type, the use of characters specific to Romanian versus standard Roman characters, ... in different issues are corrected for.

missing firm-owner-year-entries under restriction that the full ownership structure cannot exceed 100%. In case of time gaps between entries for the same owner-firm combination but with a different share-size we assume that changes show up immediately in the database. We then fill out the gaps with the older information.[4]

Data are deflated using industry price level data at Nace rev.1.1 2-digit level[5]. These are taken from the Industrial Database for Eastern Europe from the Vienna Institute for International Economic Studies and from the Statistical Yearbook of the Romanian National Statistical Office (RNSO). IO tables for the period 1996–2005 were obtained from the RNSO. The tables are in national industry classification, but the RNSO provided a mapping into Nace rev. 1.1. Real output Y is measured as operating revenues deflated by producer price indices of the appropriate Nace industry; real material inputs M, are deflated by a weighted intermediate input deflator where the industry-specific weighting scheme is drawn from the IO tables. Labor L is expressed as the number of employees. Real capital K is measured as fixed assets, deflated by the average of the deflators for the following five Nace industries: machinery and equipment (29); office machinery and computing (30); electrical machinery and apparatus (31); motor vehicles, trailers, and semi-trailers (34); and other transport equipment (35) (see Smarzynska Javorcik, 2004).

The dataset is trimmed for outliers by calculating annual growth rates of real operating revenues, real capital, labour, and real material inputs and then removing the top and bottom percentiles for each variable. If the "outlier" is the first or last observation for a specific firm, the other firm-year data are kept, if not the firm is entirely dropped from the dataset. Our preferred dataset is further reduced by excluding firms with on average less than 5 employees over the sample period. Table 1 lists the annual number of firms, and the entry and exit rate of all firms and for the subsample of foreign firms. The share of foreign firms in the total number of sample firms steadily increased from 16% to 22% (10 to 15% if small firms are not excluded). Most of the foreign entry takes the form of "greenfield" investment, in the sense that the firm immediately enters the dataset as a foreign firm. Our dataset contains 377 acquisitions, i.e. a switch from domestic to foreign ownership. The 2003 exit rate is high, but this pattern is confirmed by the pattern in the Romanian Trade Register (Trade Register data also include agriculture and services though). Table 2 lists summary statistics both for

[4] Alternatively, we assume that it takes time for changes to get noted and that they show up ex post in the database. We then fill out the gaps with the more recent information. e.g.

	Amadeus	immediate	ex post
2000	40	40	40
2001	.	40	50
2002	50	50	50

Results based on the "ex post" assumption are available in on request.

[5] *Nomenclature générale des activités économiques dans les Communautés européennes.*

domestic and foreign firms. The stylized facts commonly found in the literature are confirmed in our dataset. Foreign firms are larger in terms of employment and capital, produce more output and are more productive. The latter holds across different estimation techniques. The productivity bonus of foreign over domestic firms ranges between 14% in case of the Olley-Pakes methodology (OP) and 36% in case of the Levinsohn-Petrin methodology (LP). Table 3 indicates a fairly high correlation between the tfp-measures resulting from different estimation techniques. For our empirical results we will mainly rely on the tfp measure obtained by the methodology proposed by Ackerberg et al. (2008). Finally, table 4 shows the sector breakdown of the spillover variables for the first and last year of our sample. Left aside the highly concentrated tobacco industry (Nace 16)[6], on average (over industries) some 15% of industry output was produced by foreign firms in 1995. The share of foreign firms varies between 7% and 30%. In 2005 on average 39% of industry output was produced by foreign firms, while shares varied between 15% and 57% across industries. The correlation across years and spillovers is limited.

4 Results

4.1 The impact of entry timing

< insert table 5 and 6 >

Table 5 presents the estimation results for a baseline, non-dynamic specification as found in the literature. The first four columns all use the tfp measure resulting from the ACF methodology and differ in either the sample size (including or excluding firms with less than 5 employees on average) or in the definition of the spillover variables (share or dummy version). The backward spillover effect is significant and positive in all four estimations. This suggests that Romanian manufacturing firms have benefited from supplying foreign firms. Horizontal spillovers are positive and significant, especially when the share definition is used (columns 1 and 3). The presence of foreign competitors seems to have contributed positively to domestic firms' productivity growth. The forward spillover is also only significant when the share version is used. It is negatively signed, implying that firm-level productivity is lower for firms in industries that source inputs from industries with a larger foreign presence. Columns 5 to 7 generally confirm these findings using tfp measures obtained using other methodologies (DPD, OP, LP).

[6]Including or excluding the tobacco industry does not affect our results.

In table 6 we allow FDI spillovers to differ according to the timing of entry of the foreign firm. In order not to reduce the time dimension of our panel too much[7], we created for each spillover a 4+ variable that brings together all foreign firms that have been present for at least four years on the domestic market. One could think of the coefficient of this variable as an aggregate longer term effect. Further note that the average values of these 4+ variables are considerably larger than the variables capturing entry in a more recent specific year. We need to take this into account when interpreting coefficients and the variables' contribution to firm-level productivity growth. Gauging across specifications and different tfp measures, the results generally suggest that the positive horizontal spillover is an effect on a longer horizon. Firms that recently entered the domestic economy have no or in some specifications a negative effect, whereas firms that have been present for more than four years generate strong positive spillovers that are significant in all 7 columns of table 6. This is a clear indication that it takes time for domestic firms to adjust to new competition and novelties introduced by foreign entrants. Longer established foreign firms on the other hand positively affect domestic firm productivity. The backward spillover presents a different story. Here the impact on domestic firm productivity is faster than for the horizontal spillover, although it still seems to take a year before positive effects are observed. The strongest positive backward spillovers are found for foreign firms that entered between one and two years ago. There is a smaller, but still positive effect for firms entering between two and four years earlier, but the evidence is more mixed across samples and tfp measures. A longer term effect is absent. This suggest that domestic firms that supply new foreign entrants enjoy higher productivity growth for a couple of years, but only after a short adjustment period. With respect to the forward spillover no significant impact remains.

Focusing on columns (1) to (4), the results again slightly differ between the share and dummy versions. The share versions seem to be more indicative of a time pattern than the dummy versions. Therefore we focus on the role of ownership structure in more detail in the next section.

4.2 The impact of ownership structure

Since the dummy version abstracts from any ownership structure detail, whereas the share version does not, the different results for dummy and share versions in table 6 indicate that ownership structure may matter. On the one hand, local participation in a foreign investment project reveals the foreign firm's proprietary technology, which facilitates spillovers (Blomström and Sjöholm, 1999). On the other hand, the fear of technology leakage on be-

[7] E.g. in case of $Horizontal^{6}_{jt}$ we observe firms that have been present between 5 and 6 years on the domestic market only from 2001 onwards, prior to 2001 this variable only contains missing values.

half of the foreign firm will induce foreign firms to bring in less advanced technology or to shy away from shared ownership when bringing in their more sophisticated technologies. Desai et al. (2004) for example find evidence that majority subsidiaries receive more intangible property from their parent companies than do minority foreign owned firms. Furthermore, advanced technologies offer a larger scope for spillovers, but may impede knowledge diffusion to local firms operating in the same sector if the latter lack sufficient absorptive capacity. With respect to backward spillovers Smarzynska Javorcik and Spatareanu (2008) find positive effects only for spillovers from minority foreign owned firms. They argue that due to greater technological sophistication majority foreign owned firms may require more complex inputs that may be more difficult for local firms to provide. Therefore, they may be less likely to engage in local sourcing than affiliates with shared ownership.

Therefore we allow spillovers to differ for majority and minority foreign owned firms. This is done by considering two versions of (1) where our single foreign ownership variable F_{it} is now broken down in two versions F_{it}^M and F_{it}^m. F_{it}^M is the share of majority foreign participation (50% or more) in firm i in year t, and is set to zero if foreign participation is smaller than 50%. Likewise F_{it}^m is then the share of minority foreign participation (less than 50%, but more than 10%) in firm i in year t, and is set to zero if foreign participation exceeds 50% or is smaller than 10%. Dummy variable versions of F_{it}^M and F_{it}^m can be defined by replacing a positive share with 1.

$$Horizontal_{jt}^M = \frac{\sum_{i \in j} F_{it}^M * Y_{it}}{\sum_{i \in j} Y_{it}} \tag{10}$$

$$Horizontal_{jt}^m = \frac{\sum_{i \in j} F_{it}^m * Y_{it}}{\sum_{i \in j} Y_{it}} \tag{11}$$

(10) and (11) can then be used to generate both majority and minority foreign owned versions of all the previously defined spillover variables along the lines of (1)-(6).

Table 7 presents the results for the split between majority and minority foreign owned firms, but still abstracting from entry timing patterns. Whether the foreign investment is conducted by majority or minority foreign owned firms has a considerable impact on the sign and magnitude of the associated spillover. This conclusion is very robust over different samples (columns 1 to 4) and alternative tfp measures (columns 5 to 7). In case of horizontal spillovers, it turns out that only majority foreign owned firms generate clear positive spillovers, whereas minority foreign owned firms generate insignificant negative spillovers. Probably the more advanced technology brought in by majority foreign owned firms gener-

ates larger technology spillovers to domestic firms. The backward spillover is positive and significant for both types of foreign ownership, but point estimates reveal a much higher impact of minority foreign owned firms, in line with Smarzynska Javorcik and Spatareanu (2008). However, calculating the actual contribution of foreign investment to the productivity of Romanian firms with point estimates and sample averages reveals that the impact from majority foreign-owned firms was actually larger, essentially because the amount of majority foreign investment was much larger (see table 2). The negative forward spillover effect is entirely due to sourcing inputs from majority foreign owned firms. Probably these inputs are too complex and possibly too expensive for domestic firms to deal with.

< insert table 7 and 8>

In table 8 we jointly consider ownership structure and timing of entry effects. The dynamic effects of minority and majority foreign entry on the productivity of local competitors and local suppliers that are implied by specification (1) in table 8 are visualised in figure 4 below. The positive horizontal spillover effect from table 5 appears to be largely driven by a long term positive spillover effect from majority foreign owned firms. This result is very robust across samples and measures of tfp. The horizontal spillover from majority foreign owned firms turns negative if they entered between t-1 and t-2 and significantly negative if they entered between t-2 and t-3.This is reversed in the longer run, where the spillover turns strongly positive. This is consistent with the thesis that the advanced technology of majority foreign owned firms drives the positive spillover, but that it takes time and effort to absorb this advanced technology. It is also consistent with a labour market theory of spillovers. Majority foreign owned entrants may initially push up local wages and poach the best talents, yielding a negative spillover. But a few years later local employees that have received on the job training from the majority foreign owned firm may quit to join domestic firms or set up their own firm, reversing the effect. The productivity spillovers from minority foreign owned firms are much smaller (they also account for a substantially smaller share of industry output). The initial impact seems to be insignificant, but the spillover turns strongly negative for firms that entered between t-3 and t-4. Taking into account average values of the variables concerned, we may conclude that the spillovers from minority foreign owned firms are fairly small relative to these from majority foreign owned firms (cf. figure 4).

Minority foreign owned firms, however, do generate immediate and strong positive backward spillover effects. The first two years after entry domestic firms enjoy a substantial contribution to productivity growth. Bearing in mind the summary statistics, the large coefficient is not surprising. As testified by figure 4, this points to a considerable impact on

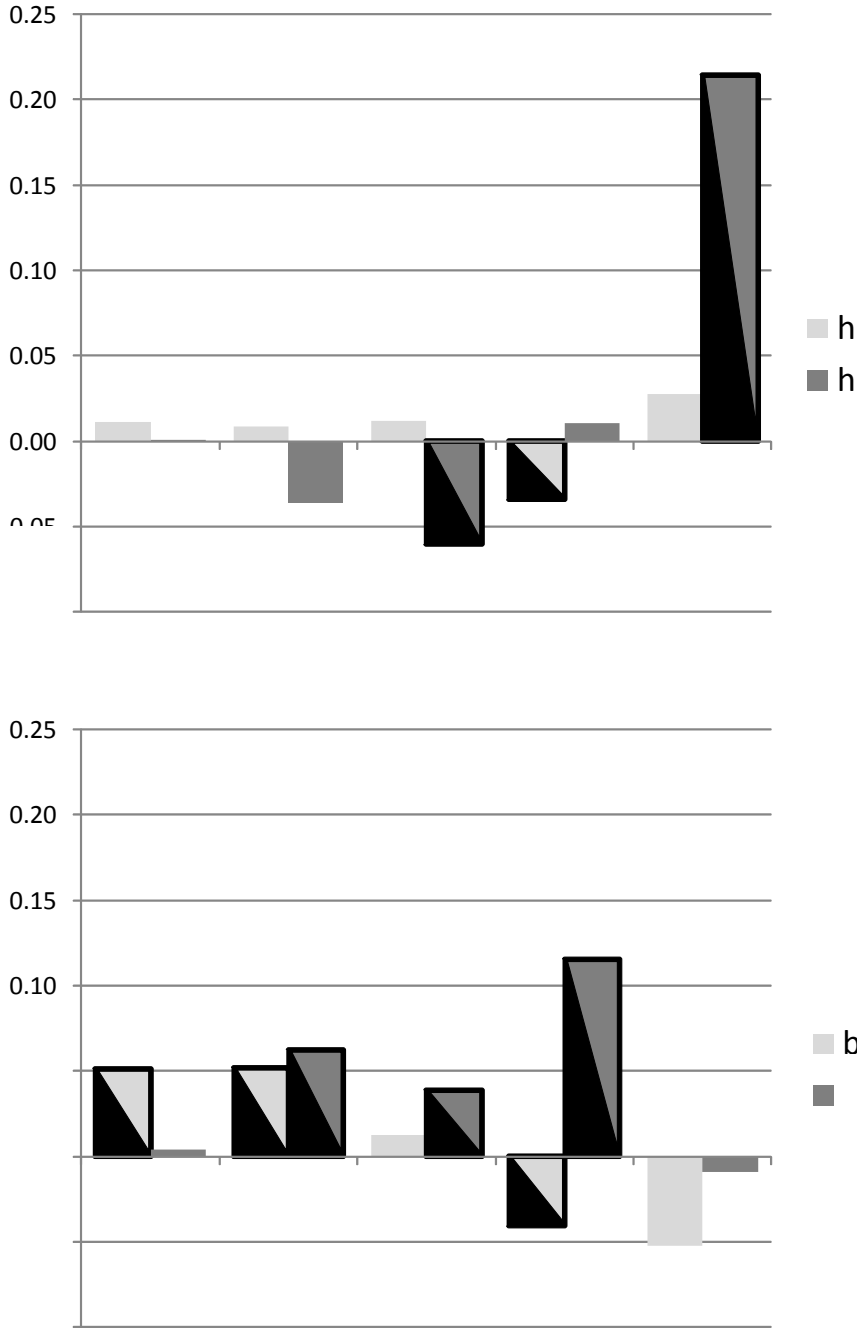

Figure 4: Impact of a one standard deviation increase in the respective spillover variables on local firm productivity implied by specification (1) of table 8 (bold borders indicate statistically significant coefficients; average log productivity of domestic firms is 5.62)

productivity growth, but altogether not an unrealistically large one. The positive backward spillover is large but short-lived. The effect even turns significantly negative if the minority foreign owned firms entered between t-3 and t-4, although the coefficient remains comparatively small. The longer run coefficients are negative but not significantly different from zero. Backward spillovers from majority foreign owned firms are also positive, but the effect is less immediate and longer lived than for minority foreign owned firms. Majority foreign owned firms need to be present for at least a full year for domestic firms to grasp positive backward spillover effects, but positive effects are enjoyed up to 4 years after foreign entry. The longer run coefficients are again insignificant.

These results are consistent with the thesis that domestic firms receive immediate, well tailored assistance from the minority foreign owned entrant they supply. Given a domestic majority, the minority foreign owned firms are probably better aware of possible constraints at their domestic suppliers and more willing to provide assistance. The foreign minority shareholder may on the other hand not bring in its most advanced technologies, implying a limited scope for spillovers. Hence an immediate, but rather short-lived positive contribution to productivity growth. For domestic firms supplying to majority foreign owned firms it may take more time to benefit from this relationship, because they need to get acquainted with the demands and technologies of their majority foreign owned clients, but benefits are large and positive once they arrive and they last longer. A lasting impact is absent as well, however.

With respect to forward spillovers the strongly negative impact on productivity of sourcing inputs from majority owned foreign firms previously observed in table 7 disappears when timing is taken into account. There seems to be a negative impact from firms that entered between t-1 & t-2 but the statistical support is at best mixed. The absence of strong forward spillover effects is in line with most of the literature (see e.g. Smarzynska Javorcik, 2004, and Smarzynska Javorcik and Spatareanu, 2008).

5 Conclusions

This study analyzes horizontal and vertical productivity spillovers of foreign direct investment on domestic Romanian manufacturing companies from 1996 to 2005. We add to the literature by relaxing the assumption that spillovers are constant and permanent. We allow the spillovers to vary over time according to the timing of foreign entry. We find that spillovers from foreign investments indeed vary over time in ways that are economically intuitive and consistent with economic theory. In the short run backward spillovers seem to dominate the analysis, but in the longer run horizontal spillovers emerge as important channels of productivity spillovers too. More specifically, domestic firms seem to experience

positive horizontal spillover effects from majority foreign owned firms, but only in the longer run. This is consistent with the thesis that domestic firms need time and effort to absorb the foreign technology, but also with the labour market channel of spillovers. The horizontal impact of minority foreign owned firms, who account for a substantially smaller share of industry output, is much smaller. Minority foreign owned firms do generate immediate and strong positive backward spillover effects though. The first two years after entry, domestic firms that supply minority foreign entrants enjoy a substantial contribution to productivity growth, but this positive impact fades out rather quickly. Backward spillovers from majority foreign owned firms are also positive, but the effect is less immediate and longer lived, though it also fades out in the longer run. We do not find strong evidence for the existence of forward spillovers, a finding that is in line with most of the literature. Attracting foreign direct investment therefore raises the level of local firm productivity, but contrary to what the literature has implictly been assuming the impact of foreign presence depends strongly on its maturity.

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	All firms			*of which Foreign firms*			
	# firms	entry	exit	# firms	entry	exit	penetration
1996	14,393			2,242			0.16
1997	15,618	1057	91	2,615	315	32	0.17
1998	16,768	996	190	3,005	328	59	0.18
1999	18,054	1200	761	3,464	373	169	0.19
2000	19,480	1845	301	3,940	472	72	0.20
2001	20,908	1374	507	4,458	445	119	0.21
2002	21,912	1224	988	4,792	332	305	0.22
2003	22,579	1336	2447	4,896	298	493	0.22
2004	21,525	1066	562	4,831	314	168	0.22
2005	20,963			4,667			0.22

Table 1: Number of firms, entry, and exit by year

	All firms		Domestic firms		Foreign firms	
	n = 133154		n = 105854		n = 27300	
	mean	sd	mean	sd	mean	sd
ln(real output)	13.74	1.90	13.53	1.84	14.52	1.94
ln(employment)	98.97	432.98	83.11	394.16	160.49	554.31
ln(capital)	12.08	2.32	11.82	2.26	13.06	2.29
ln(real value added)	12.67	2.09	12.43	2.03	13.62	2.05
ln(tfp) *ACF*	5.74	1.52	5.69	1.52	5.95	1.47
ln(tfp) *OP*	2.09	0.87	2.06	0.85	2.20	0.94
ln(tfp) *LP*	6.93	1.79	6.86	1.81	7.22	1.70
ln(tfp) *DPD*	2.30	1.29	2.27	1.27	2.42	1.33
ln(tfp) *OLS*	2.43	1.01	2.39	0.98	2.61	1.10
ln(tfp) *FE*	2.00	0.96	1.95	0.91	2.21	1.11

	Spillovers (industry-year; n = 649)					
	all foreign owned firms		majority foreign owned firms		minority foreign owned firms	
	mean	sd	mean	sd	mean	sd
horizontal *dummy*	0.40	0.16	0.26	0.21	0.06	0.12
horizontal *share*	0.28	0.14	0.22	0.19	0.02	0.04
backward *dummy*	0.24	0.07	0.17	0.08	0.04	0.05
backward *share*	0.17	0.05	0.15	0.07	0.01	0.02
forward *dummy*	0.26	0.09	0.17	0.09	0.05	0.03
forward *share*	0.18	0.08	0.14	0.08	0.01	0.01

Table 2: Summary statistics for firm-level and industry level variables

	OLS	FE	DPD	Lpva	OP
FE	0.87				
DPD	0.69	0.60			
Lpva	0.57	0.39	0.69		
OP	0.91	0.75	0.68	0.58	
ACF	0.67	0.54	0.50	0.87	0.65

Table 3: Correlation between different productivity measures

	1996				2005			
Nace	# *firms*	*horizontal*	*backward*	*forward*	# *firms*	*horizontal*	*backward*	*forward*
15	4,138	0.22	0.11	0.07	4,712	0.40	0.20	0.19
16	3	0.00	0.10	0.02	17	0.85	0.23	0.09
17	695	0.10	0.11	0.04	1,024	0.45	0.27	0.16
18	1,509	0.17	0.11	0.10	2,671	0.43	0.24	0.37
19	501	0.17	0.06	0.07	1,082	0.56	0.18	0.26
20	1,324	0.08	0.09	0.07	1,989	0.46	0.22	0.12
21	193	0.13	0.17	0.06	282	0.42	0.28	0.23
22	807	0.23	0.16	0.12	1,016	0.34	0.14	0.19
23	17	0.18	0.10	0.10	28	0.57	0.25	0.18
24	432	0.13	0.13	0.12	517	0.42	0.27	0.21
25	528	0.15	0.10	0.06	859	0.34	0.24	0.13
26	530	0.11	0.09	0.10	815	0.24	0.24	0.25
27	158	0.13	0.09	0.08	220	0.43	0.26	0.22
28	1,281	0.09	0.08	0.09	2,101	0.25	0.25	0.34
29	437	0.08	0.09	0.10	640	0.29	0.26	0.37
30	104	0.30	0.12	0.10	132	0.13	0.23	0.18
31	203	0.16	0.08	0.09	348	0.50	0.19	0.23
32	61	0.18	0.09	0.04	84	0.51	0.29	0.28
33	154	0.07	0.16	0.12	231	0.15	0.27	0.32
34	149	0.07	0.06	0.10	209	0.55	0.18	0.36
35	133	0.17	0.05	0.11	268	0.49	0.09	0.37
36	1,036	0.16	0.15	0.09	1,718	0.36	0.21	0.35

Table 4: Values for horizontal, forward, and backward in 1996 and 2005)

	(1) ACF share > 5L	(2) ACF dummy > 5L	(3) ACF share all	(4) ACF dummy all	(5) DPD share > 5L	(6) OP share > 5L	(7) LP share > 5L
horizontal	1.390***	0.684**	1.341***	0.539	0.392***	0.363**	1.366***
	[0.399]	[0.306]	[0.454]	[0.337]	[0.143]	[0.142]	[0.401]
backward	2.168**	1.583**	2.332**	1.493**	1.103***	1.037***	2.137**
	[0.875]	[0.677]	[0.952]	[0.719]	[0.281]	[0.292]	[0.881]
forward	-3.039***	-0.895	-3.334***	-1.139	-1.118***	-1.212***	-3.047***
	[0.964]	[0.752]	[0.939]	[0.756]	[0.346]	[0.360]	[0.964]
N	81002	81002	132084	132084	108482	108430	88071
R-squared	0.091	0.086	0.073	0.068	0.054	0.054	0.098

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition and firm age. The dependent variable is first-differenced firm level TFP based on first-step production function estimates by industry according to the indicated methodology. Columns (2) and (4) use the dummy version of the spillover variables. All columns are based on the sample of firms with on average more than 5 employees, except columns (3) and (4) that are based on the sample of all firms. Robust t-statistics in brackets; */**/*** denotes significance at 10/5/1 percent.

Table 5: Time invariant spillover effects

	(1) ACF Share > 5L	(2) ACF dummy > 5L	(3) ACF share all	(4) ACF dummy all	(5) DPD share > 5L	(6) OP share > 5L	(7) LP share > 5L
entry ...							
horizontal							
after t-1	0.500	0.096	0.976	0.221	0.012	0.068	0.494
	[0.729]	[0.553]	[0.795]	[0.636]	[0.247]	[0.257]	[0.750]
between t-1 & t-2	-1.178	-0.627	-1.100	-0.906	-0.580**	-0.622**	-1.199
	[0.828]	[0.537]	[0.923]	[0.591]	[0.266]	[0.280]	[0.838]
between t-2 & t-3	-1.368*	-0.473	-1.219*	-0.784	-0.582**	-0.594**	-1.373*
	[0.756]	[0.567]	[0.690]	[0.525]	[0.236]	[0.243]	[0.771]
between t-3 & t-4	0.673	0.215	0.448	-0.118	0.077	0.074	0.688
	[0.548]	[0.509]	[0.535]	[0.508]	[0.144]	[0.147]	[0.555]
before t-4	2.046***	1.221***	1.999***	1.023**	0.383***	0.380***	2.007***
	[0.415]	[0.329]	[0.508]	[0.400]	[0.113]	[0.113]	[0.418]
backward							
after t-1	5.102	0.104	4.134	-0.286	2.093	2.358*	4.727
	[4.205]	[2.372]	[4.572]	[3.172]	[1.350]	[1.368]	[4.287]
between t-1 & t-2	9.463***	5.031**	8.898***	5.075*	3.350***	3.424***	9.503***
	[3.277]	[2.440]	[3.248]	[2.637]	[1.118]	[1.117]	[3.378]
between t-2 & t-3	3.900*	1.841	3.997*	2.024	1.727**	1.823***	3.652
	[2.206]	[1.401]	[2.367]	[1.462]	[0.693]	[0.697]	[2.223]
between t-3 & t-4	5.635*	1.739	4.322*	1.353	2.496***	2.538***	5.546*
	[2.974]	[1.741]	[2.330]	[1.398]	[0.799]	[0.788]	[3.029]
before t-4	-0.665	-0.379	0.028	0.034	0.159	0.063	-0.662
	[1.208]	[1.017]	[1.257]	[1.021]	[0.362]	[0.366]	[1.233]
forward							
after t-1	0.358	-0.253	0.799	0.226	0.515	0.359	0.346
	[2.103]	[1.495]	[2.153]	[1.508]	[0.604]	[0.612]	[2.077]
between t-1 & t-2	-0.455	-0.127	-1.279	-0.772	-0.527	-0.593	-0.447
	[1.206]	[1.103]	[1.233]	[1.083]	[0.372]	[0.382]	[1.197]
between t-2 & t-3	-0.586	-1.561	-1.357	-1.967	-0.315	-0.352	-0.550
	[2.297]	[1.646]	[2.322]	[1.730]	[0.675]	[0.676]	[2.286]
between t-3 & t-4	0.817	1.595	-0.927	0.507	-0.156	-0.294	0.938
	[2.455]	[2.284]	[2.469]	[2.147]	[0.710]	[0.730]	[2.509]
before t-4	1.038	1.620*	0.602	1.066	0.417	0.393	1.158
	[0.997]	[0.881]	[0.999]	[0.892]	[0.311]	[0.313]	[0.996]
N	51561	51565	82385	82389	65373	65346	55002
R-squared	0.068	0.060	0.051	0.045	0.036	0.039	0.066

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition and firm age. The dependent variable is first-differenced firm level TFP based on first-step production function estimates by industry according to the indicated methodology. Columns (2) and (4) use the dummy version of the spillover variables. All columns are based on the sample of firms with on average more than 5 employees, except columns (3) and (4) that are based on the sample of all firms. Robust t-statistics in brackets; */**/*** denotes significance at 10/5/1 percent.

Table 6: Time varying spillover effects

	(1) ACF share > 5L	(2) ACF dummy > 5L	(3) ACF share all	(4) ACF dummy all	(5) DPD share > 5L	(6) OP share > 5L	(7) LP share > 5L
horizontal-maj	1.466***	1.304***	1.450***	1.315***	0.392***	0.367***	1.432***
	[0.388]	[0.342]	[0.441]	[0.384]	[0.140]	[0.140]	[0.390]
horizontal-min	-0.783	-0.189	-1.603	-0.390	-0.163	-0.177	-0.762
	[1.018]	[0.284]	[1.018]	[0.278]	[0.276]	[0.274]	[1.012]
backward-maj	1.786**	1.768**	2.092**	2.099**	0.998***	0.948***	1.749*
	[0.896]	[0.784]	[0.972]	[0.824]	[0.301]	[0.309]	[0.901]
backward-min	10.257***	3.469***	6.651	3.086***	4.172***	3.598**	10.413***
	[3.242]	[0.715]	[4.331]	[0.815]	[1.443]	[1.709]	[3.107]
forward-maj	-3.175***	-2.546***	-3.474***	-2.820***	-1.192***	-1.277***	-3.200***
	[0.977]	[0.773]	[0.965]	[0.776]	[0.363]	[0.377]	[0.977]
forward-min	4.014	1.267	1.943	0.694	1.502	1.076	4.554
	[3.325]	[1.128]	[3.781]	[1.252]	[1.283]	[1.316]	[3.308]
N	81002	81002	132084	132084	108482	108430	88071
R-squared	0.098	0.101	0.077	0.080	0.058	0.057	0.105

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition and firm age. The dependent variable is first-differenced firm level TFP based on first-step production function estimates by industry according to the indicated methodology. Columns (2) and (4) use the dummy version of the spillover variables. All columns are based on the sample of firms with on average more than 5 employees, except columns (3) and (4) that are based on the sample of all firms. Robust t-statistics in brackets; */**/*** denotes significance at 10/5/1 percent.

Table 7: Time invariant spillover effects from majority and minority owned foreign firms

	(1) ACF share > 5L	(2) ACF dummy > 5L	(3) ACF share all	(4) ACF dummy all	(5) DPD share > 5L	(6) OP share > 5L	(7) LP share > 5L
entry ...							
horizontal-maj							
after t-1	0.043	-0.194	0.517	-0.183	-0.142	-0.066	0.017
	[0.704]	[0.676]	[0.756]	[0.698]	[0.276]	[0.280]	[0.730]
between t-1 & t-2	-1.321	-1.052	-1.125	-1.192	-0.673*	-0.690*	-1.394
	[1.041]	[0.887]	[1.104]	[0.929]	[0.357]	[0.377]	[1.062]
between t-2 & t-3	-1.843**	-1.318*	-1.846**	-1.638**	-0.725***	-0.724***	-1.864**
	[0.847]	[0.749]	[0.799]	[0.751]	[0.264]	[0.275]	[0.860]
between t-3 & t-4	0.298	0.276	-0.163	-0.339	0.033	0.037	0.291
	[0.662]	[0.610]	[0.656]	[0.631]	[0.177]	[0.181]	[0.673]
before t-4	1.881***	1.700***	1.757***	1.554***	0.390***	0.392***	1.819***
	[0.369]	[0.396]	[0.442]	[0.445]	[0.108]	[0.110]	[0.370]
horizontal-min							
after t-1	8.883	0.697	17.738**	1.576	2.449	2.713	7.879
	[7.968]	[2.043]	[7.505]	[1.990]	[2.616]	[2.699]	[7.924]
between t-1 & t-2	5.129	-0.283	6.698	-0.480	2.225	2.372	4.905
	[6.374]	[1.181]	[5.630]	[1.049]	[1.984]	[2.119]	[6.244]
between t-2 & t-3	6.566	-0.789	8.407	-1.258	0.012	0.228	6.520
	[9.324]	[2.114]	[9.563]	[2.552]	[2.598]	[2.646]	[9.340]
between t-3 & t-4	-10.573**	-1.068	-14.541***	-3.541**	-5.464***	-5.070***	-11.160**
	[5.019]	[1.360]	[5.075]	[1.526]	[1.394]	[1.398]	[5.038]
before t-4	2.143	0.459	-0.773	-0.506	-0.368	-0.199	1.915
	[1.686]	[0.493]	[1.818]	[0.543]	[0.499]	[0.522]	[1.732]
backward-maj							
after t-1	2.026	2.067	-7.456	-5.270	1.080	1.129	1.288
	[6.702]	[6.100]	[7.074]	[6.319]	[2.198]	[2.245]	[6.823]
between t-1 & t-2	11.782***	12.869***	12.294**	13.507***	4.940***	5.096***	11.463**
	[4.462]	[4.361]	[4.876]	[4.766]	[1.447]	[1.465]	[4.567]
between t-2 & t-3	4.756**	1.423	4.536*	1.824	2.963***	3.002***	4.614**
	[2.272]	[2.367]	[2.497]	[2.766]	[0.784]	[0.788]	[2.294]
between t-3 & t-4	13.794***	7.103**	17.298***	11.096***	5.415***	5.448***	13.934***
	[4.429]	[3.293]	[4.094]	[3.042]	[1.248]	[1.263]	[4.487]
before t-4	-0.255	-0.324	1.029	1.634	0.465	0.366	-0.216
	[1.402]	[1.239]	[1.404]	[1.270]	[0.476]	[0.485]	[1.452]
backward-min							
after t-1	125.269**	5.767	116.361**	7.898	36.335**	43.261***	127.242**
	[52.667]	[5.469]	[50.423]	[6.183]	[16.323]	[16.472]	[52.850]
between t-1 & t-2	114.866***	10.829	84.671***	14.560**	18.874*	20.314*	113.218***
	[34.920]	[8.575]	[23.113]	[6.809]	[11.207]	[11.538]	[35.404]
between t-2 & t-3	28.776	10.583*	12.583	9.339	-9.205	-7.576	23.933
	[34.169]	[6.043]	[30.149]	[6.770]	[11.494]	[11.281]	[34.755]
between t-3 & t-4	-58.042**	-5.161	-82.159***	-11.093	-17.449**	-17.611**	-63.325**
	[24.824]	[6.403]	[27.246]	[7.073]	[7.321]	[7.337]	[25.307]
before t-4	-17.956	-3.282	-12.282	-1.653	-5.109	-4.923	-18.286
	[13.427]	[3.994]	[12.232]	[3.699]	[4.582]	[4.563]	[13.816]

	(1) ACF share > 5L	(2) ACF dummy > 5L	(3) ACF share all	(4) ACF dummy all	(5) DPD share > 5L	(6) OP share > 5L	(7) LP share > 5L
forward-maj							
after t-1	2.037	-0.224	1.030	-0.051	0.678	0.511	2.129
	[2.336]	[1.958]	[2.439]	[1.963]	[0.677]	[0.692]	[2.314]
between t-1 & t-2	-0.982	-1.240	-2.249*	-2.450**	-0.986**	-1.052**	-1.056
	[1.291]	[0.963]	[1.306]	[0.961]	[0.441]	[0.455]	[1.295]
between t-2 & t-3	1.721	0.220	0.386	0.068	0.279	0.248	1.708
	[2.941]	[2.238]	[2.838]	[2.159]	[0.830]	[0.851]	[2.925]
between t-3 & t-4	-0.157	0.302	-2.241	-1.729	-0.676	-0.809	-0.125
	[2.600]	[2.447]	[2.632]	[2.442]	[0.778]	[0.799]	[2.653]
before t-4	0.575	0.733	1.024	0.482	0.126	0.150	0.553
	[1.532]	[1.129]	[1.398]	[1.153]	[0.476]	[0.475]	[1.549]
forward-min							
after t-1	9.291	0.550	15.369	0.277	2.015	-0.268	10.124
	[21.885]	[8.272]	[20.424]	[7.962]	[6.078]	[6.130]	[21.994]
between t-1 & t-2	0.585	1.804	9.993	0.385	-2.122	-2.482	-0.198
	[13.778]	[4.979]	[12.446]	[4.787]	[3.541]	[3.680]	[13.649]
between t-2 & t-3	-7.532	-11.062	-6.293	-12.834	-6.304	-7.653	-5.717
	[26.230]	[11.949]	[28.127]	[12.687]	[6.191]	[6.415]	[26.585]
between t-3 & t-4	16.930	3.345	15.018	4.275	3.862	3.367	18.052
	[14.087]	[5.222]	[13.757]	[5.136]	[3.951]	[3.954]	[14.343]
before t-4	7.511**	1.906	4.409	-0.138	2.198*	2.063	7.895**
	[3.662]	[1.510]	[4.221]	[1.366]	[1.270]	[1.292]	[3.678]
N	49787	49787	80567	80567	63268	63241	53119
R-squared	0.085	0.076	0.055	0.06	0.044	0.047	0.084

Second-step OLS estimates for domestic firms; regressions include industry, time, and region dummies; control variables included are industry competition, import competition and firm age. The dependent variable is first-differenced firm level TFP based on first-step production function estimates by industry according to the indicated methodology. Columns (2) and (4) use the dummy version of the spillover variables. All columns are based on the sample of firms with on average more than 5 employees, except columns (3) and (4) that are based on the sample of all firms. Robust t-statistics in brackets; */**/*** denotes significance at 10/5/1 percent.

Table 8: Time varying spillover effects from majority and minority owned foreign firms